2 Robot Overview

Module Goal

The purpose of this module is to introduce the learner to Robots and the concepts associated.

INTRODUCTION

Learner will be able to:

- Identify and define the term “Robot” as well as terms commonly used with Robotics
- Summarize a brief history of robotics
- Expand upon the components of robots and explain “Degrees of Freedom”
- Identify different types of robots and their features
- Explain robot languages
- Provide an overview of robot workstations and applications

LESSON TOPICS

ROBOTICS WILL BE DEFINED

Robotics is a multidisciplinary field which combines mechanical engineering, electrical/electronic engineering, and computer science.

The combination mechanical engineering, electrical/electronic engineering, and computer science are used in the design and applications of robots.

Mechanical engineering is important to robotics in the dynamics, and construction of the manipulators of a robot which determines its range of movement and the possible motions.

Electrical engineering in robotics has to do with supplying electrical energy which is converted into mechanical energy by means of an electric motor or actuator. Electrical energy gives movement to the physical system of a robot. Electrical energy is the chemistry of atoms and the electrons that orbit them. This provides power to the robotic system.

Computer science and Electronic engineer go hand in hand giving intelligence to the robot by means of electronic sensors and computer programs that provide logical movement to the robot. Electronic control circuitry provides mediation between the computer program and the robots motors/actuators.

Cognitive Robots
Robots are becoming increasingly more advanced and engineers are working to develop robots that can “think”. Watch this video to learn more.
https://www.youtube.com/watch?v=IzD1Pv3KnIw

List the key terms that are required for the students to understand this topic and provide a definition.

Robotics is a multidisciplinary field which combine mechanical engineering, electrical/electronic engineering, and computer science. The combination of these three disciplines are used in the design and applications of robots.

Robot is a mechanical device that operates automatically or semi automatically. A “robot” is shorter term when referring to a robotic system.

Computer programs are stored on computers or controllers that provide intelligence and decision making.

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ROBOT WILL BE DEFINED

The Origin of Robots

Do you know where the word "robot" originates from?

- **a 1921 play called "Rassum's Universal Robots (RUR)"**

The word "robot" originates from a 1921 play called "Rassum's Universal Robots (RUR)" by a Czech writer named Karel Capek.

What are Robots?

A **robot** is a mechanical device that operates automatically or semi automatically. Modern robots are controlled by electronic circuitry, mechanisms, computers, and computer programs.

The purpose of a robot is to perform tasks that may be too dangerous, complex, or labor intensive for a human.

List the key terms that are required for the students to understand this topic and provide a definition.

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HISTORY OF ROBOTS

History of Robots

In 1954, George Devol designed the first programmable robot at his robotic company, Unimation, formally Universal Automation.

Unimation installed its first industrial robot in the year 1961. Competitors in the robotic industry came about including KUKA, ABB, Mitsubishi, and Fanuc.

This photo shows a Puma, one of the first robotic arms.
List the key terms that are required for the students to understand this topic and provide a definition.
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ROBOT FEATURES

Today's robots are very advanced, with sensory systems that allow them to process information and act almost as If they have a human brain. This artificial intelligence (AI) enables them to interact with and react to their environment.

Robots are made up of these components:

Effectors-devices at the end of the robot arm that allow it to interact with the environment

Sensors-measure physical quantities and converts them into signals that can be used by the robot.

Computer- “brains” of the robot

Auxiliary Equipment- tools and equipment that may be used by the robot to perform a specific task

Key terms

Effectors: devices at the end of the robot arm that allow it to interact with the environment

Sensors: measure physical quantities and converts them into signals that can be used by the robot.

Computer: “brains” of the robot

Auxiliary Equipment: tools and equipment that may be used by the robot to perform a specific task

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COMPONENTS OF ROBOTS

Today’s robots are advanced, with sensory systems that allow them to process information and to act almost as if they have a human brain. This artificial intelligence (AI) enables them to interact with and react to their environment.

Robots are made of the following components:

Effectors – devices at the end of a robot arm that allow it to interact with the environment

Sensors – measures physical quantities and converts signals that can be used by the robot

Computers – the "brains" of the robot

Auxiliary Equipment – tools and equipment that might be used by the robot to perform a specific task

Manipulator/Arm

The arm of the robot is referred to as the manipulator which interacts indirectly with its environment.

Mechanisms are used in robots to transfer mechanical energy which provides potential motion and movement. Mechanism include gears, pulleys, and actuators.

End-effector

The end-effector is the component at the end of a robotic arm that interacts directly with its environment. This could be a gripper, vacuum, or needle.

Controller

A computer desktop or laptop can be connected directly to the controller via Ethernet cable to download or upload programs. The computer program is first written on the computer, and simulated before running it on the robot.

The computer program gives logical intelligence and decision making to the robot.

Electronic signals are used as communication between the computer program and the hardware being monitored or controlled.

Electronic control circuitry convert electronic signals from the program into larger electrical energy that drives the motors and actuators of a robotic system.

Hardware interfacing provides a physical or wireless connection for communicating between the controller and the electronic sensors and control circuitry.

Electronic control circuitry communicates with the controller by means of electronic signals. The control circuitry bridges the logic of the program to energize actuators that inhibit movement.

Robotic sensors are used for many tasks including:

Hearing
Sight
Touch
Taste
Smell

Sensors

Electronic sensors translate the robots environment into electronic signals which are used in the computer program. Sensors are used to determine temperature, force, pressure, sight, position, radiation levels or any variable that may need to be addressed for a robotic system to perform a certain task.

Some robots can even taste! The prime minister of Thailand was tired of bad Thai food in other countries so the government developed a robot that can evaluate the authenticity of Thai food.

Another robot tongue can identify types of beer and even check alcohol content.
Experts are trying to use robo-tongues in the quality control areas of breweries.

Actuators

Actuators convert energy from the forms of pneumatics (air pressure), or electricity into mechanical energy or movement. Actuators can be identified as pneumatic cylinders, hydraulic cylinders, and electric motors.

Electric motors convert electrical energy into mechanical energy for rotary or linear movements.

Motors can be connected directly to a joint, called direct drive, or connected to a gear box to increase the torque or speed of the joint movement. Motors can be powered by alternating current, or direct current which is supplied by a power supply.

Pneumatically actuated cylinder means to extend or retract a piston inside a cylindrical chamber with pressurized air. Pneumatic cylinders require an air compressor to supply pressurized air. A valve is used to direct the pressurized air in or out of the pneumatic cylinder. This controls the piston to extend or retract.

These actuators are controlled by the controller but use the energy from their supply for movement, whether it is a power supply for electricity or an air compressor for pressurized air.

Teach Pendant

A teach pendant interfaces the user with the robot controller. The teach pendant allows the user to teach the robots positions, adjust various settings and parameters, manually control the robot, and view the programs saved on the controller.

A teach pendent is used to control a robot remotely. The emergency stop button, or the E-stop, allows the operator to shut down the robot if there is a problem. The program display screen shows the current operation mode and saved programs. The jog buttons allows the operator to easily adjust the speed and movement. Arm transverse keys correspond to XYZ coordinates and drive the robot arm in a designated direction.

Power Supply

Many of the robots components require electricity to operate. Power supplies are commonly connected to wall outlets which supply alternating current with a voltage of around 120 Volts. The electronic components within the power supply transform the electricity from the wall into an amount which is required to power the various components. For example, motors and actuators commonly use a larger amount of electricity than the robot controller and sensors.

List the key terms that are required for the students to understand this topic and provide a definition.

Manipulator

Controller

Processor Motors Actuators Sensors Pendant Power supply
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DEGREES OF FREEDOM

Degrees of Freedom

The **degrees of freedom** is the number of possible movements a robot can perform at a given time.

The number of joints and axes determine the degrees of freedom. One joint or axes equal one degree of freedom.

How Many Degrees?

How many degrees of freedom does each of the below robots have? Drag the number of degrees of freedom to each corresponding robot, then click Submit.

List the key terms that are required for the students to understand this topic and provide a definition.

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TYPES OF ROBOTS

Types of Robots

Robot kinematics is the arrangement of solid bodies that are linked together by joints which define the robots movement. Robot arms can be categorized base on how these solid bodies are linked together with rotary and linear joints. These joints are referred to as axis (singular), or axes (plural). Linear axes move in straight lines along the X, Y, or Z planes. Rotary axes move in a circular motion similar to a human arm where the elbow or knee are the rotary axes (Refer to a diagram of the differences).

Robots generally have a base or a foundation that anchors to a workstation.

From the base, robots have a combination of rotary axes and linear axes connected in series or parallel.

The arrangement of these axes create a three dimensional shape that defines the robots range of motion. This three dimensional space is called the operating envelope or work envelope. The operating envelope can be thought of as the robots boundaries in which it can operate within (Refer to diagram of a Robot).

The last component of the manipulator interacts directly with the environment is called an end-effector. The arm of the robot is also referred to as the manipulator.

Articulated Robot

Articulated robots are identified as having at least three rotary joints connected in “series” or “daisy chained” together from the base

Articulated robots are most commonly found in an industrial setting. The articulated robot is used in a wide range of applications from assembly operations to welding.

Cartesian Robot

Cartesian robots are also found in industry, although this robot moves linearly, in a straight line with an operating envelope defined by the Cartesian coordinate system. The Cartesian coordinate system relies on linear motion along the X, Y, and Z axes that create the boundaries of the operating envelope. As shown in the diagram “the axes are connected at right angles of each other” (Cartesian coordinate system, WIKI). This type of robot is used in the application of pick and place, assembly, machine tooling, laser cutting, drawing, milling, welding.

A Cartesian robot that is supported on both sides of the up and down axes (Z), are known as Gantry robots. Gantry robots are used in laser cutters and engravers, 3D printers, and milling machines.

Gantry Robot
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Gantry robots are used in laser cutters and engravers, 3D printers, and milling machines.

Cylindrical Robot

A cylindrical robot can be identified as having one rotary axis connected to the base, followed by two linear axis.

This configuration of axes form a cylindrical operating envelope, allowing the robot to operate in confined spaces.

This robot is used in the applications of welding, assembly, machine tooling, fettling, and die casting.

Polar Robot

Polar robots are also known as spherical robots. This type of robot can be identified by having a linear axis connected to the base followed by two rotary axes in series for movement in the XY planes (Refer to the Polar Robot image).

This arrangement of axes define an operating envelope based on the polar coordinate system.

The polar coordinate system is defined by the Pythagorean theorem and vectors. Polar robots are used in the applications of machine tooling, welding, fettling, and die casting.

SCARA Robot

"SCARA" stands for Selective Compliance Assembly Robot Arm. This type of robot has one linear axis for the Z plane, and two rotary axes in parallel for movement in the XY planes.

This arrangement of parallel rotary joints provides an advantage in the applications of assembly, and pick and place. A SCARA robots range of motion is similar to a human arm making it easier to maneuver in and out of confined spaces.

Delta Robot

A delta robot, also referred to as a parallel robot, has three rotary axes all connected to an overhead base with arms extending from each joint. Each arm is connected to an end-effector forming a pyramid or delta shape.

This configuration is significant in that the end piece is always "parallel" with the ground, or workstation. This type of robot is especially useful in the applications of high speed pick and place.

https://www.youtube.com/watch?v=zSUQvTvmhtk

https://www.youtube.com/watch?v=vtAEIKJLHGw

Humanoid Robot

A humanoid robot is one in which it's structural features closely resemble a human body but may not have all features. An android is a humanoid robot that replicates all human features.

A humanoid robot may have a combination of the previously discussed robots.

This type of robot is used in many applications such as human interaction, study of biomechanics, prosthetics, and even human cognition. Human cognition is how humans learn from observing its surroundings using sensory details, and obtain better perceptual and motor skills.

List the key terms that are required for the students to understand this topic and provide a definition.

Linear axes

Rotary axes

Articulated

Cartesian

Cylindrical

Polar

SCARA

Delta

Humanoid Robot

Available Resources:

Robot Classifications with good illustrations

http://www.engineershandbook.com/Components/robclasscartesian.htm

Delta Robot

https://www.youtube.com/watch?v=zSUQvTvmhtk

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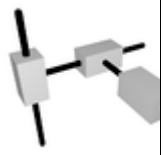
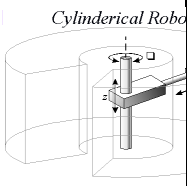
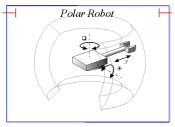
 **ATTRIBUTION:** "Descartes configuration.png" by Nikola Smolenski is licensed by CC BY 1.0.			
cylindrical2.GIF  **NO ATTRIBUTION**	NASA	http://prime.jsc.nasa.gov/ROV/images/cylindrical2.GIF	Public Domain
sphericalpolar.GIF  **NO ATTRIBUTION**	NASA	http://prime.jsc.nasa.gov/ROV/images/sphericalpolar.GIF	Public Domain
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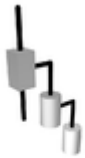 **ATTRIBUTION:** "SCARA configuration.png" by Nikola Smolenski is licensed by CC BY 1.0.			
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ROBOT WORKSTATION

Workstations allow operators to interface with robotic systems that may be located remotely, in areas that are hazardous for humans to occupy or in cleanroom systems. The operator is able to control and manipulate the robot using joysticks, LCD displays, teach pendants and computer systems.

List the key terms that are required for the students to understand this topic and provide a definition.

Workstations: allow operators to interface with remote robotic systems.

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ROBOT LANGUAGES

Robots are given logical decision making through computer programming. Computer programs are written on the computer in software that is specific to a robots processor. The structure and text of the program is referred to as the computer program language. There are many different kinds of programming languages including the Industrial Robot Language (IRL), and C++. Some robots have a dedicated programming language different from the standard or traditional languages. A computer program is a set of instructions that are carried out depending on certain variables. Computer programs take in electronic signals from sensors and perform computations and logical statements that result in an outgoing electronic signal to control circuitry which control motors and actuators.

List the key terms that are required for the students to understand this topic and provide a definition.

IRL – Industrial Robot Language

How Do Robots "Talk"?

In this video, two robots are working together. How do you think they communicate with each other?

Robot Languages

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A computer program is a set of instructions that are carried out depending on certain variables. Computer programs take in electronic signals from sensors and perform computations and logical statements that result in an outgoing electronic signal to control circuitry which control motors and actuators.

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ROBOT APPLICATIONS

Robots are used in various applications including the handling, loading, unloading, and transfer of material, welding, painting, assembly, testing and many more applications.

List the key terms that are required for the students to understand this topic and provide a definition.

Applications: how something is used

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SUMMARY

Robots used in industrial applications are programmed to perform a number of labor intensive, monotonous, and dangerous jobs. One major factor that must be considered when incorporating any new form of technology into an already developed field is whether the advantages outweigh the disadvantages. Such as, does the return on investment constitute making the initial investment or do the potential hazards and maintenance costs introduced by the robots outweigh the increased productivity and quality of the product? There are multitude applications which robots can be used for, ranging from welding and grinding to nuclear material handling and injection molding, which are briefly discussed in this section and the advantages associated with them.

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LABS

Provide an overview of labs that are required. Include any links to labs that are available for review.

QUIZ

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FURTHER STUDY

STATEMENTS

This workforce solution was funded by a grant awarded by the U.S. Department of Labor's Employment and Training Administration. The solution was created by the grantee and does not necessarily reflect the official position of the U.S. Department of Labor. The Department of Labor makes no guarantees, warranties, or assurances of any kind, express or implied, with respect to such information, including any information on linked sites, and including, but not limited to accuracy of the information or its completeness, timeliness, usefulness, adequacy, continued availability or ownership.